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B3F FPG
U1S S1612 S1974

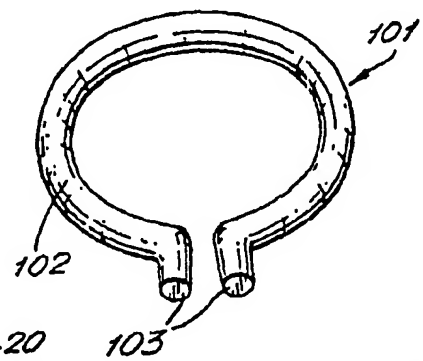
(56) Documents cited
GB 2067938 A   GB 1564738 A   GB 1375528 A
EP 0224672 A1   US 4374538 A

(58) Field of search
UK CL (Edition K) B3F FPG
INT CL[5] B22D
Online databases: WPI

(54) Making a casting using a frangible core

(57) A casting including an interior cavity defined by a frangible core (101) wherein the casting is cast around the core (101) which is subsequently broken, preferably shattered, to leave the so-defined interior cavity within the casting. In the preferred embodiment, which is directed to a furnace tuyere, the shattered core is flushed from the casting using a high pressure fluid. The core may be shattered using an explosively-generated shock wave which, also in the preferred embodiment, is provided by an explosive threaded through at least part of the hollow core prior to detonation.

FIG.3.



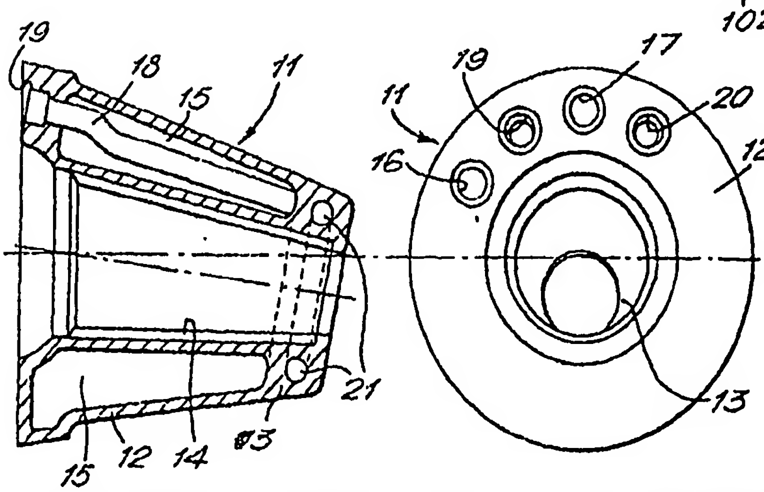


FIG.1.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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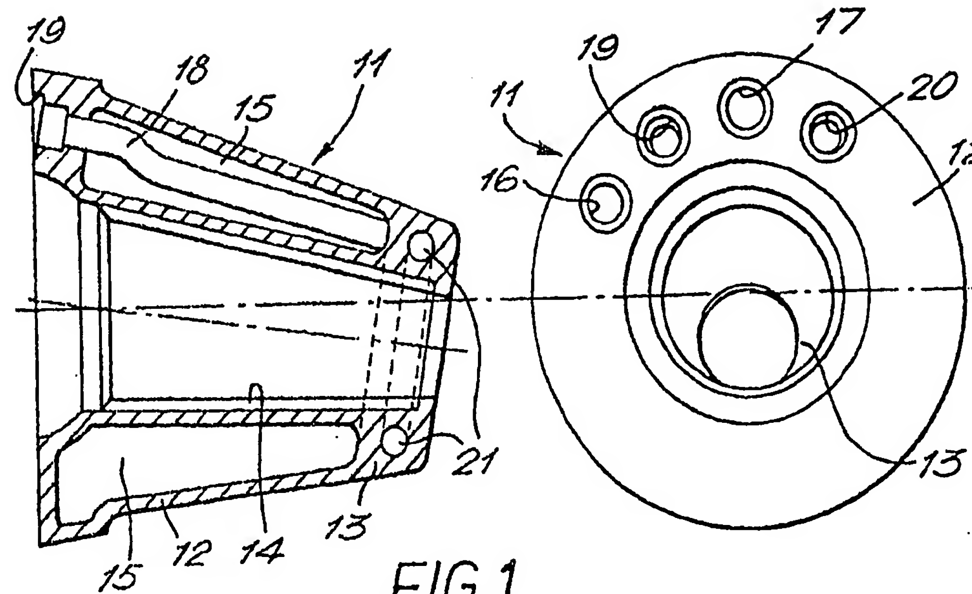
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FIG.1.

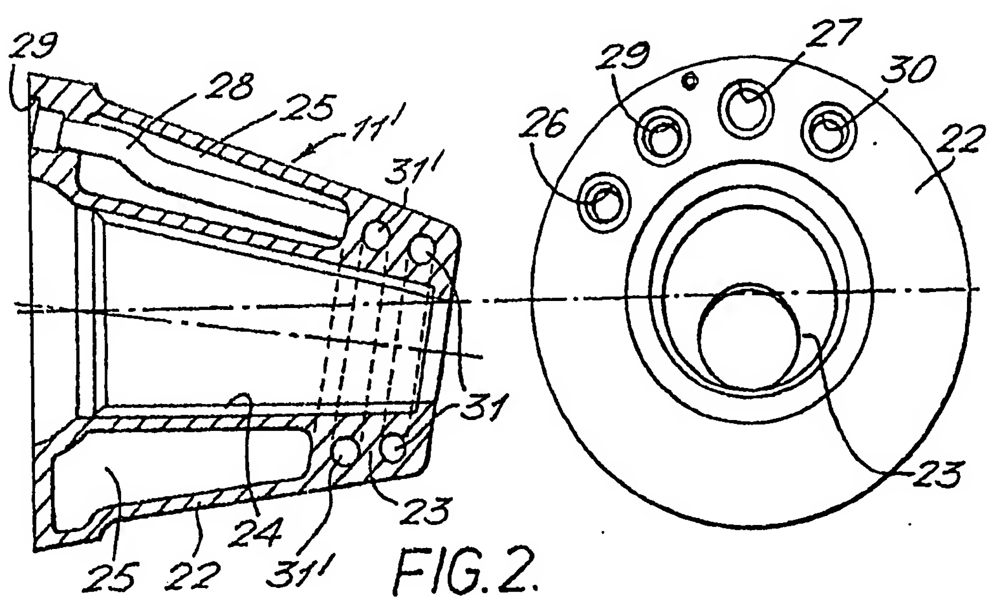
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FIG.2.

FIG.3.

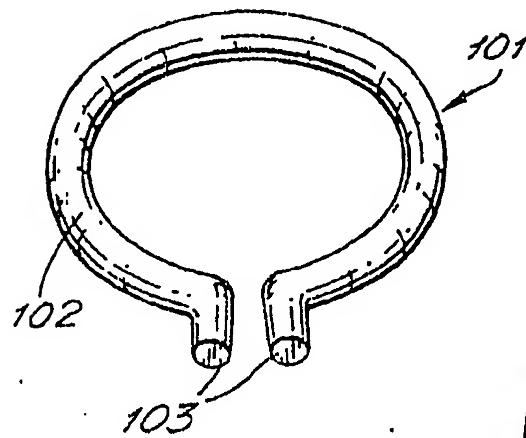


FIG.4.

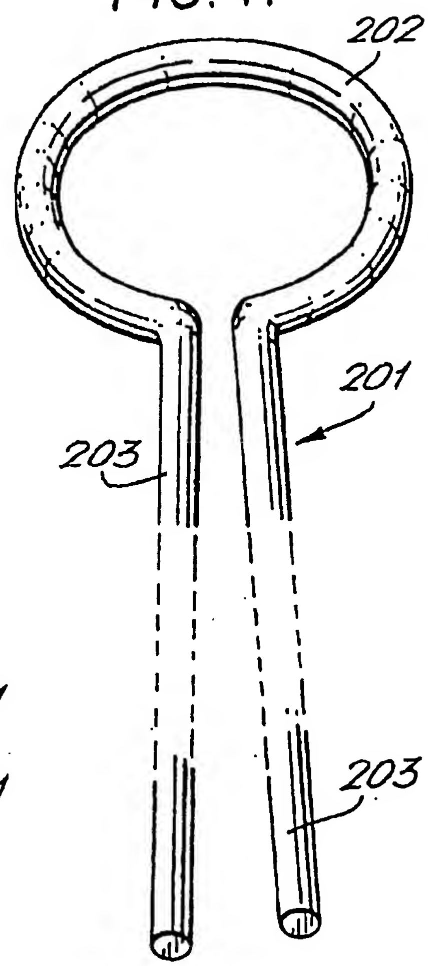
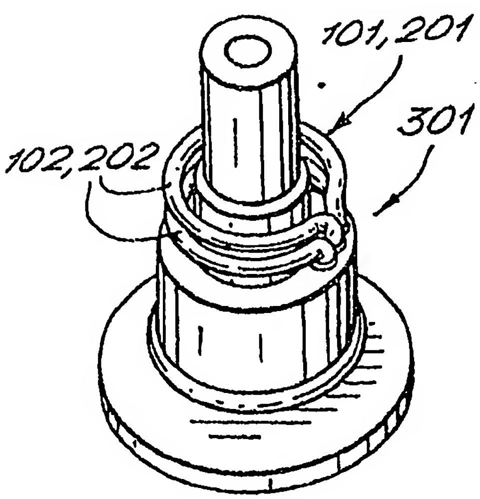


FIG.5.



CASTINGS

DESCRIPTION

This invention relates generally to castings having formed therein at least one chamber, bore or other enclosed space or cavity. Especially, but not exclusively, the invention relates to consumable furnace components and their manufacture, wherein one or more internal bores and/or chambers are provided for the circulation of a coolant, such as, water, a typical example of such a component being a tuyere which is cast from copper and which has at least one copper tube in the nose thereof for the passage of water coolant therethrough. This type of tubular coolant passage is also used in other forms of copper-cast, consumable furnace component, such as, a tuyere cooler.

In existing copper-cast tuyeres, problems have arisen in providing a consistent and continuous metallurgical bond between the copper coolant tube(s) and the copper casting in which the tube is embedded, to provide good overall heat transfer characteristics. Where there is bad bonding between the copper tube(s) and the casting, "hot spots" build-up, giving rise to poor cooling, and hence thermal erosion of, the working surface of the nose of the tuyere in the region of the badly bonded areas. Also, voids in these areas tend to form, thereby reducing the heat transfer characteristics even further.

Various methods have been used to try and provide consistent and continuous metallurgical bonding between the copper tubes and surrounding cast copper but without complete success. For instance, the explosive bonding between respective confronting surfaces

of the copper tube(s) and casting has been attempted but this technique has resulted in rupturing of the tube(s) by the explosive, as well as uneven bonding characteristics.

In British Patent Specification No. 1564738, there is described a tuyere having a smooth coolant flow path through the nose thereof, which has been formed by a removable frangible core around which the tuyere nose has been cast, the preferred material for the core being specified as furane sand. However, this type of core has to be maintained in the required position with respect to the tuyere mould by means of a suitably shaped copper rod and associated tie bars, resulting in the presence of the rod and portions of the tie bars in the coolant flow path formed by the subsequently removed core, during service of the tuyere. Such presence provides an obstruction in the so-formed coolant flow path, thereby reducing the cooling efficiency of the tuyere. Moreover, it has been found that complete removal of the frangible core is very difficult and, in some instances, impossible, thereby resulting in further obstruction of the coolant path, with additional reduction in coolant flow and, hence, overall cooling efficiency.

It is an object of the present invention to overcome, or at least substantially reduce, the disadvantages discussed above in relation to known castings, particularly of copper, where smooth and continuous coolant passages, chambers and/or other internal spaces or cavities are required.

Throughout this specification, the term "cavity" will be used to embrace any form of chamber, bore or other enclosed space located within a casting,

whether the casting is of copper, other metal or alloy or any other castable material.

In accordance with one aspect of the present invention, there is provided a casting including an interior cavity defined by a frangible core, around which the casting has been cast and which has been broken, preferably shattered, for subsequent removal from the casting.

In accordance with a second aspect of the present invention, there is provided a method of manufacturing a casting including an interior cavity, wherein a castable material is cast around a frangible core defining the cavity and, subsequent to such casting, the core is broken, preferably shattered, for subsequent removal from the casting.

Advantageously, the broken core has been shattered into particles which may be removed from the cast cavity by any suitable means, for instance, by flushing with water or by a high pressure jet of air or other gas, via, say, ports communicating the cavity with the exterior of the casting.

Preferably, the core is shattered into particulate form using an explosively-generated shock wave, although other methods, such as, acoustic methods, for example, high frequency acoustic vibrations, for instance, at ultrasonic frequencies, may also be employed.

In accordance with a third aspect of the invnetion, there is provided a cast, consumable furnace

component including a coolant passage or other cavity therein, which is defined by a frangible core around which the component has been cast and which has been broken, preferably shattered, subsequent to such casting.

A fourth aspect of the invention provides a method of manufacturing a cast, consumable furnace component including a coolant passage or other cavity therein, wherein a metallic material, preferably copper, is cast around a frangible core defining the coolant passage or other cavity and, subsequent to such casting step, the core is broken, preferably shattered.

Again, the broken, preferably shattered, core may be removed from the cast component by flushing with water or by using a high pressure jet of air or other gas or fluid.

In a preferred embodiment, wherein the consumable furnace component is a cast copper tuyere, the core defining, say, the generally circular coolant passage(s) in the nose of the tuyere and/or the associated coolant inlet and outlet passages communicating therewith, is made of quartz, preferably that sold under the name of VITREOSIL (Registered Trade Mark), and is tubular with a circular cross-section, although other cross-sections may be employed, depending upon particular operating conditions of the tuyere.

However, any other suitably frangible material may be used, glass or ceramics being typical.

In this embodiment, however, the quartz tubing is subjected to an explosively-generated shock wave, to render it into fine particulate form for subsequent removal by flushing with water.

The preferred explosive is a flexible elongate one comprising a core of powdered explosive encased within a flexible sheath of plastics material (CORDTEX), which can be threaded through at least part of the explosively-frangible

quartz core via, say, the coolant inlet passage, the coolant passage(s) in the nose and the coolant outlet passage of the cast tuyere, and then detonated to shatter the quartz core into small particulate form for subsequent removal from the casting, as described above.

It has been found that the use of preformed quartz tubing for the shaped core and the elongate explosive described above, yields fine particles of quartz after shocking the core, thereby facilitating removal. Indeed, the shocked quartz could be almost "powdered" in form in some instances.

The resulting coolant passage or passages within the cast tuyere have been found to be very smooth, thereby enhancing coolant flow therethrough and, thus, improving the heat transfer characteristics of the tuyere in service.

Further, the problems and disadvantages discussed above in relation to the use of preformed, cast-in coolant tubes are eliminated.

In order that the invention may be more fully understood, embodiments in accordance therewith will now be described by way of example and with reference to the accompanying drawings in which:

Figure 1 is a double chamber tuyere manufactured in accordance with the invention;

Figure 2 is a triple chamber tuyere manufactured in accordance with the invention;

Figure 3 is a core for use in manufacturing

each of the tuyeres shown in Figures 1 and 2, in accordance with the invention;

Figure 4 is another form of core for manufacturing each of the tuyeres shown in Figures 1 and 2, in accordance with the invention; and

Figure 5 is a perspective view of a mould in a partially-formed state, used in the manufacture of the triple chamber tuyere shown in Figure 2.

Referring firstly to Figure 1, here there are shown respective sectional (left-hand) and plan (right-hand) views of a copper-cast, double chamber tuyere indicated generally at 11 and comprising a body 12 and a nose 13 cast integrally therewith. Passing generally axially through the tuyere body 12 and nose 13 is a bore 14 of tapering cross-section. In service of the tuyere 11, air is passed at a rapid rate through the bore 14 into a blast furnace (not shown) with which the tuyere 11 is associated and into which the nose 13 projects.

Coolant water is passed through a generally annular cooling chamber 15 in the body 12 of the tuyere 11 via respective inlet and outlet ports 16,17, as well as through respective copper inlet and outlet tubes which are cast into the tuyere 11 during manufacture and of which only the inlet tube 18 is shown. Respective inlet and outlet ports 19,20 are provided in the rear of the tuyere body 12 for the inlet (18) and outlet tubes which communicate with a generally circular cooling tube 21 located in the nose 13 of the tuyere 11. During manufacture of the tuyere 11, the circular, nose tube 21, which may be formed integrally with or be brazed or welded to the inlet (18) and

outlet tubes, is also cast into the copper tuyere nose 13.

Referring now to Figure 2 of the drawings, here is illustrated respective sectional (left-hand) and plan (right-hand) views of a copper-cast, triple chamber tuyere indicated generally at 11' and, as in the case of the double chamber tuyere 11 described above in relation to Figure 1, comprising a body 22, a nose 23 and a generally axially-extending bore 24 of tapering cross-section, together with a substantially annular cooling chamber 25 with respective inlet and outlet ports 26,27.

In the nose 23 of the tuyere 11', however, there are two circular cooling tubes 31,31' fed with coolant water by a copper inlet tube 28 and provided with a copper outlet tube (not shown), as in the case of the double chamber tuyere 11 described above with reference to Figure 1. Similarly, respective inlet and outlet ports 29,30 are provided at the rear of the tuyere body 22 for the copper inlet (28) and outlet tubes communicating with the two cooling tubes 31,31' in the nose 23.

In service, the triple chamber tuyere 11' operates ina similar manner to that in which the double chamber tuyere 11 operates, except that the triple chamber tuyere 11' exhibits a greater cooling characteristic, due to the presence of the additional cooling tube 31' in the nose 23 thereof.

In both types of tuyere 11,11' described above, the inlet 18,28 and outlet tubes extend through the separate, annular cooling chambers 15,25, in order to enhance the overall cooling characteristic.

However, and as discussed above, the cast-in, generally circular cooling tubes 21 and 31,31' in the nose 13,23 of each tuyere 11,11', and in certain instances, the associated inlet 18,18' and outlet tubes, do not always provide a perfect metallurgical bond with the surrounding parent copper, resulting in a decrease in cooling efficiency, erosion of the nose 13,23 and, in certain circumstances, rupture of the tubes with consequential loss of coolant water and severely reduced flow thereof.

Accordingly, and as also indicated above, the present invention sets out to overcome these disadvantages associated with known tuyeres and their method of manufacture by having the cooling tubes 21 and 31,31' in the tuyere noses 13,23 and/or the associated inlet 18,28 and outlet tubes formed by an acoustically frangible core, as will now be described with reference to the remaining Figures 3 to 5 of the accompanying drawings.

In Figure 3, there is shown a tubular, quartz tube 101 formed into the generally circular shape of the copper cooling tubes 21 and 31,31' used in the noses 13,23 of the respective tuyeres 11,11' described above with reference to Figures 1 and 2.

When the mould from which a tuyere is cast, is made, this tubular quartz core 101 is used to replace the or each copper cooling tube 21,31,31' of the prior art tuyeres described above. In addition to the substantially ccircular portion 102 of the quartz core 101, there are provided two depending straight portions 103 which are arranged to communicate with the copper inlet 18,28 and outlet tubes in the tuyere bodies 12,22.

Alternatively, and when the inlet and outlet tubes are otherwise located in the parent copper of the tuyere bodies 12,22, another form of core may be used, as shown in Figure 4. Here, the quartz core 201 comprises a generally circular portion 202 of tube and two long straight extensions 203 thereof. Thus, in this particular form of core 201, the circular portion 202 represents and subsequently forms or defines the or each cooling tube in a tuyere nose 13,23, whilst the extensions 203 represent and subsequently form or define the associated inlet 18 and outlet tubes in the tuyere body 12,22.

In Figure 5, there is shown a partially-formed mould from which a triple chamber tuyere is cast from copper, with two quartz cores, such as those described above with reference to Figure 3 or 4, located in the desired position. The circular portion 102,202 of each quartz core 101,201 forms or defines the respective tubes 31,31' in the nose 23 of the tuyere which is to be eventually cast from the completed mould.

The so-cast tuyere comprises a copper body 22 and a copper nose 23 integral therewith, as well as the cast-in, tubular quartz cores 101 or 201, depending upon the particular design of the inlet and outlet tubes of the tuyere 11'.

In order to remove the two cast-in, quartz cores 101 or 201, a length of flexible elongate explosive, such as that sold under the trade name CORDTEX (Registered Trade Mark), is threaded into the tuyere via either the inlet port 29 or outlet port 30 at the rear of the tuyere body 22, so that the explosive is located in register with the corresponding lengths of the two cores 101 or 201.

Then, under suitably safe conditions, the explosive is detonated at one end thereof, whereby the resultant shock wave generated within the cores 101 or 201 by the detonating explosive shatters the quartz, from which the cores are made, into fine particles resembling a white powder which is subsequently removed from the tuyere by flushing it with water or by using a high pressure jet of air.

In this manner, it has been found that all, or at least substantially all, the particulate quartz can be removed from the tuyere.

Also, this inventive method of removing the quartz tube cores is much better than prior art methods using frangible cores, such as, quartz cores, for the forming of cavities within cast components, wherein the cast-in cores are leached out with a suitable acid which might also attack the material from which the actual component has been cast. Further, such known leaching methods are slow and, hence, unnecessarily time consuming.

An inventive casting, such as, the tuyere described above or other consumable furnace component, made in accordance with the inventive method of manufacture, has a respectively-formed cavity, such as, the circular cooling tube(s) or bore(s) in the tuyere nose and/or inlet and outlet tube(s) or bore(s) in the tuyere body, has a surface which is extremely smooth and substantially free from pits or other types of fault, resulting, in the case of consumable furnace components, such tuyeres and tuyere coolers, in increased cooling characteristics and greater durability.

It is to be understood that modifications

may be made to the inventive castings and related methods of their manufacture described above. For instance, the acoustically-frangible material from which the cores are made, may be selected such that ultrasonic energy can be used to break it down, preferably into the smallest possible particles. Also, the invention may be employed to manufacture castings other than those described above with reference to the drawings.

CLAIMS

1. A casting including an interior cavity defined by a frangible core around which the casting has been cast and which has been broken, preferably shattered, subsequent to such casting.

2. A casting according to claim 1, wherein the core has been shattered using an explosively-generated shock wave.

3. A casting according to claim 2, wherein an explosive has been located at least partially within a cavity-defining, hollow core and has been detonated to generate the shock wave.

4. A casting according to claim 3, wherein the explosive has been threaded through at least part of the hollow core prior to detonation.

5. A casting according to any preceding claim, wherein the shattered core has been flushed from the casting, preferably using a high pressure fluid.

6. A casting according to any preceding claim which is a cast copper consumable furnace component, preferably a tuyere, wherein the interior cavity defined therein is a coolant passage.

7. A method of manufacturing a casting including an interior cavity, wherein a castable material is cast around a frangible core defining the cavity and, subsequent to such casing, the core is broken, preferably shattered.

8. A method according to claim 7, wherein the core is shattered using an explosively-generated shock wave.

9. A method according to claim 8, wherein an explosive is located at least partially within a cavity-defining hollow core and is then detonated to generate the shock wave.

10. A method according to claim 9, wherein the explosive is threaded through at least part of the hollow core prior to detonation.

11. A method according to any of claims 7 to 10, wherein the broken core is flushed from the casting, preferably with a high pressure fluid.

12. A cast, consumable furnace component including a coolant passage or other cavity therein, which is defined by a frangible core around which the component has been cast and which has been broken, preferably shattered, subsequent to such casting.

13. A component according to claim 12, wherein the core has been shattered using an explosively-generated shock wave.

14. A component according to claim 13, wherein an explosive has been located at least partially within a cavity-defining, hollow core and has been detonated to generate the shock wave.

15. A component according to claim 14, wherein the explosive has been threaded through at least part of the hollow core prior to detonation.

16. A component according to any of claims 12 to 15, wherein the shattered core has been flushed from the component, preferably using a high pressure fluid.

17. A component according to any of claims 12 to 16, which is a tuyere.

18. A method of manufacturing a cast, consumable furnace component including a coolant passage or other cavity therein, wherein a metallic material, preferably copper, is cast around a frangible core defining the coolant passage or other cavity and, subsequent to such casting step, the core is broken, preferably shattered.

19. A method according to claim 18, wherein the core is shattered using an explosively-generated shock wave.

20. A method according to claim 19, wherein an explosive is located at least partially within a cavity-defining hollow core and is detonated to generate the shock wave.

21. A method according to claim 20, wherein the explosive is threaded through at least part of the hollow core prior to detonation.

22. A method according to any of claims 18 to 21, wherein the shattered core is flushed from the casting, preferably using a high pressure fluid.

23. A cast consumable furnace component substantially as hereinbefore described with reference to the accompanying drawings.

24. A method of manufacturing a cast, consumable furnace component substantially as hereinbefore described.